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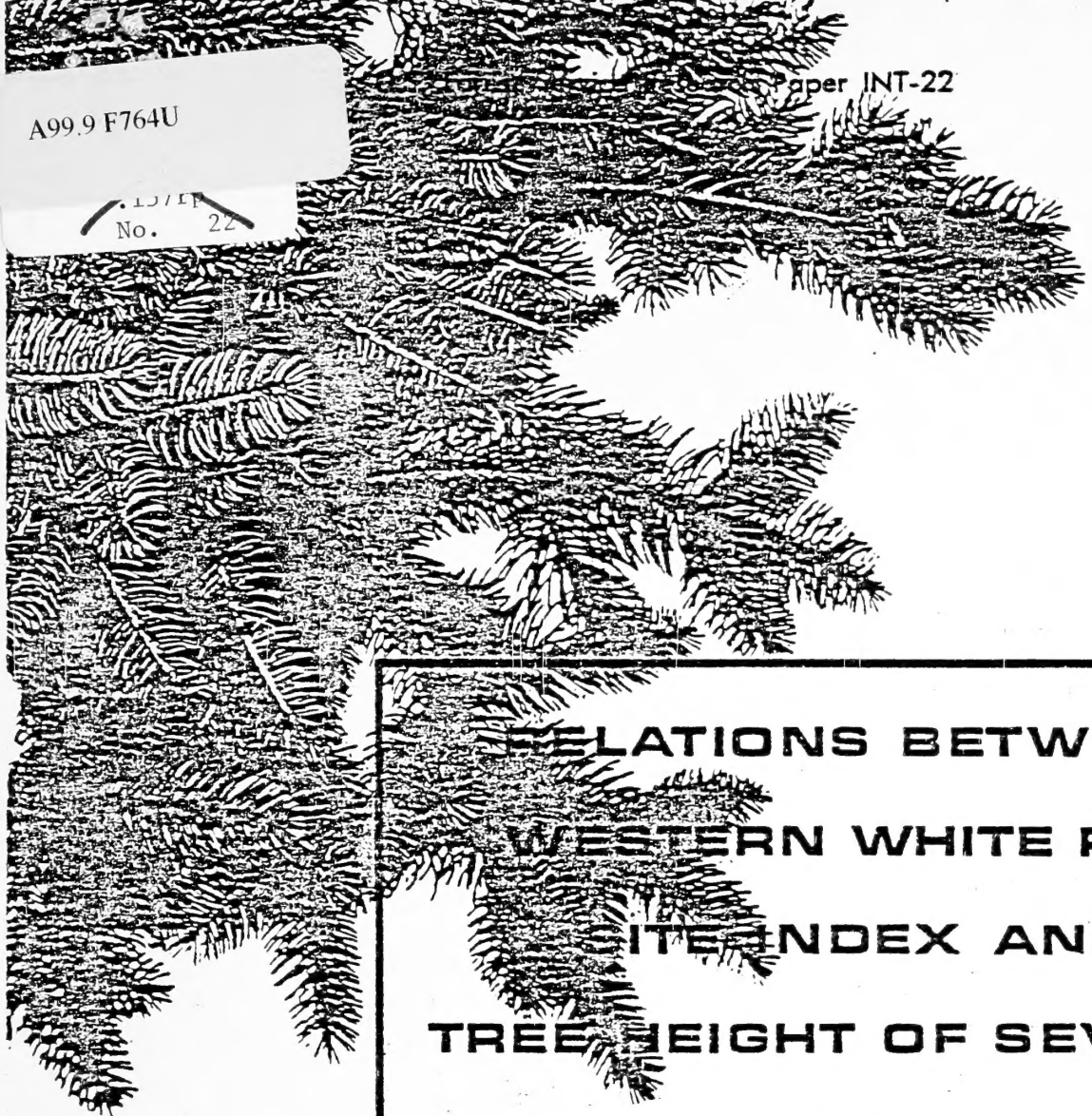

RELATIONS BETWEEN WESTERN WHITE PINE SITE INDEX AND TREE HEIGHT OF SEVERAL ASSOCIATED SPECIES

by
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THE PROBLEM

The western white pine (*Pinus monticola* Dougl.) forest type occupies about 2.4 million acres of commercial forest land in the northern Rocky Mountain region. Another 2 million acres or more could grow white pine, but the species is not present in quantity because of past cutting practices or quirks of nature.

Management on these areas is difficult for several reasons. White pine silvicultural practices have been especially complicated by blister rust disease. Sites now occupied by white pine, or that could grow it, generally rank quite high in terms of production potential, but the characteristic steep slopes and rough topography cause frequent and abrupt changes in site quality. Also, species composition on land capable of growing white pine is typically complex: as many as 10 species occur on some sites. Common associates of white pine are Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco), western larch (*Larix occidentalis* Nutt.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), grand fir (*Abies grandis* (Dougl.) Lindl.), western redcedar (*Thuja plicata* Donn), lodgepole pine (*P. contorta* Dougl.), Engelmann spruce (*Picea engelmannii* Parry), and subalpine fir (*Abies lasiocarpa* (Hook) Nutt.).

The wide representation of species offers the forest manager considerable latitude in choosing a particular species or combination of species to favor in future stand management. Sound economic decision in management planning requires knowledge of how the performance of available alternative species compares on specific sites. It is therefore important to know the comparative height-growth capabilities because height is presently the best single indicator of site or yield capacity.

Methods for estimating comparative heights have been developed for some of the species capable of growing on white pine land. From these, two important kinds of information can be obtained. First, a prediction of height growth of alternate species can be made from information on white pine performance; second, on lands where white pine is scarce or absent, the capacity of the land to grow it can be estimated from known heights of alternate species. This information should be useful in establishing preferential guides for planting and thinning operations.

METHODS

PLOT DESCRIPTIONS

One hundred and eight permanent plots in northern Idaho western white pine stands extending from the Kaniksu National Forest to the Clearwater National Forest were selected for analysis. These plots provided sufficient height data on white pine and other species to be considered usable for this study. The plots ranged in size from 0.1 acre to 2.0 acres and had been measured at 5- or 10-year intervals over varying lengths of time — some for as long as 40 years. Most of the plots were at elevations between 2,000 and 4,000 feet above sea level, but 13 were at higher elevations, some approaching 5,000 feet. Nearly 90 percent occupied topographic positions classified as upper, middle, and lower slope; the remainder were classified as ridge and flat (or bench) locations.

By the ecological classification developed by Daubenmire,[1] the majority of plots fell into the *Thuja-Tsuga/Pachistima* habitat type. The only other types represented were *Abies grandis/Pachistima* and *Thuja/Pachistima*, each with about 10 percent of the plots.

From the 108 plots, we had a total of 483 recorded observations of height of western white pine and trees of associated species. These records include some remeasurements of several trees at different ages. Adequate data for analysis were found for five of white pine's common associates — western larch, lodgepole pine, Douglas-fir, grand fir, and western hemlock. Western hemlock and lodgepole pine had fewer than half as many measured height comparisons as the others, but the important age-class range between 20 and 80 years was quite well represented (table 1).

[1] *Daubenmire, R. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecol. Monog. 22:301-330. 1952.*

Table 1. — Number of observations of comparative height between western white pine and other species, by age class

Age class (years)	Western larch	Lodgepole pine	Douglas-fir	Grand fir	Western hemlock
21-40	28	14	34	38	26
41-60	82	61	80	79	30
61-80	116	41	106	77	29
81-100	39	2	27	35	23
101-120	2	0	12	16	8
121-140	3	0	9	11	0
Total	270	118	268	256	116

STATISTICAL METHODS

Multiple linear regression analysis was used to develop equations for (1) estimating the height of five alternative species from site data that included western white pine height or site index, and (2) estimating western white pine site index from known heights of the alternate species. The variables entering into the analyses are noted below.

Estimating Height of Alternative Species

The dependent variable was the average height of dominant and codominant trees at given stand age for any single species other than white pine. Thirteen independent variables were included in the gross analyses for each species:

1. **Western white pine site index (WPSI[2]):** Determined from stand measurements and reference to published site index curves.[3] Watt[4] had already verified validity of these curves for general application.

2. **Stand age (A):** As defined by Haig,[5] the age of the oldest tree, providing it does not differ by more than 3 years from the age of the next oldest tree.

[2] *Abbreviated variable designation as used in subsequent equations.*

[3] *Haig, Irvine T. Second-growth yield, stand, and volume tables for the western white pine type. U.S. Dept. Agr. Tech. Bul. 323, 67 pp. 1932.*

[4] *Watt, Richard F. Second-growth western white pine stands: site index and species changes; normality percentage trends; mortality. U.S. Dept. Agr. Tech. Bul. 1226, 60 pp. 1960.*

[5] *Haig, op. cit.*

3. Reciprocal of stand age (1/A).

4. Reciprocal of western white pine site index (1/WPSI)

5. Product of western white pine site index and stand age (WPSI·A)

6. Ratio of western white pine site index to stand age (WPSI/A)

7. Elevation above sea level (E)

8. Reciprocal of elevation (1/E)

9. Aspect: Expressed as the sine (SinAz) or cosine (CosAz) of the average azimuth reading.

10. Habitat type (HT): A discrete variable limited to only three habitat-type conditions: *Abies/Pachistima*, *Thuja/Pachistima*, and *Thuja-Tsuga/Pachistima*.

11. Topographic position (TP): A discrete variable having five categories: ridge, upper slope, middle slope, lower slope, and flat or bench.

12. Western white pine height (WPht): Average height of measured dominant and codominant white pine.

13. Ratio of western white pine height to stand age (WPht/A)

Estimating Western White Pine Site Index

Seven of the nine independent variables used in this second series of analyses were the same as in the first; i.e., stand age and its reciprocal, elevation and its reciprocal, aspect, habitat type, and topographic position. The other variables were:

1. Height of other species: Average height of measured dominant and codominant trees of given species — western larch (WLht), lodgepole pine (LPht), Douglas-fir (DFht), grand fir (GFht), or western hemlock (WHht).

2. Ratio of other-species height to stand age (WHht/A, etc.)

Values for the two nonquantifiable variables, habitat type and topographic position, were calculated by assigning orthogonal coefficients to each habitat type and topographic position. The partial regression coefficient obtained from the regression for habitat type and topographic position multiplied by the orthogonal coefficient assigned each habitat type and topographic position gives the value of each.

RESULTS

PREDICTING HEIGHTS OF ASSOCIATED SPECIES

Two equations are presented below for each of the five alternative species. Equation I, based only on stand age and white pine site index, or white pine height alone, provides a simplified means of estimating heights of other species without serious lack of accuracy. Graphs for making specific predictions and a table showing general height comparisons among species are in Appendix A. These cannot be used in a reverse order; that is, white pine site index cannot be predicted from other species' height and stand age. The series of equations in the next section are for that purpose.

Equation II includes all significantly related variables that give increases in accuracy of estimates worthy of consideration. Because of the more lengthy computations and more specific site measurements needed, use of Equation II will generally be limited to situations requiring the best possible estimate for small and quite homogeneous areas. Condensed tabular values given in Appendix B will facilitate calculations.

Western Larch Equation I:

$$WLht = +22.6 + 0.79(WPSI) + 0.74(A) - 1{,}200(1/WPSI) - 17(WPSI/A)$$

For this equation, $R^2 = 0.87$; $S\bar{y} = \pm 8.2$ feet.

Western Larch Equation II:

$$WLht = -148.4 + 1(WPSI) + 0.80\,(A) + 1{,}400(1/A) - 1{,}200(1/WPSI) - 38(WPSI/A) + 0.019(E) + 260{,}000(1/E) + 3.1(CosAz) + HT\ value^{6} + TP\ value^{6}$$

Abies/Pachistima	−9	Ridge	+12
Thuja/Pachistima	+6	Upper slope	+1
Thuja-Tsuga/Pachistima	+3	Middle slope	0
		Lower slope	−1
		Flat or bench	−12

$R^2 = 0.91$; $S\bar{y} = 7.1$ feet.[7]

Lodgepole Pine Equation I:

$$LPht = +15.8 + 0.81(WPht)$$

$R^2 = 0.87$; $S\bar{y} = \pm 6.5$ feet.

Lodgepole Pine Equation II:

$$LPht = -65.3 - 800(1/A) - 210(1/WPSI) + 0.016(E) + 170{,}000(1/E) + 6(CosAz) + 0.66(WPht) + HT\ value + TP\ value$$

Abies/Pachistima	+6	Ridge	−1
Thuja/Pachistima	0	Upper slope	−3
Thuja-Tsuga/Pachistima	−6	Middle slope	+5
		Lower slope	+4
		Flat or bench	−5

$R^2 = 0.93$; $S\bar{y} = \pm 5.2$ feet.

Douglas-Fir Equation I:

$$DFht = +69.3 - 500(1/A) - 1{,}200(1/WPSI) + 0.0108(WPSI \cdot A) - 11(WPSI/A)$$

$R^2 = 0.92$; $S\bar{y} = \pm 7.6$ feet.

[6] *Insert the appropriate value for habitat type and topographic position as listed below each equation in which they occur.*

[7] *R^2, the coefficient of determination, multiplied by 100 gives the percent of the variation in tree height that is explained by the independent variables used. $S\bar{y}$ is the standard deviation from regression.*

Douglas-Fir Equation II:

$$DFht = +58.5 - 1{,}300(1/WPSI) + 0.0121(WPSI \cdot A) - 16(WPSI/A) + HT\ value + TP\ value$$

Abies/Pachistima	0	Ridge	+4
Thuja/Pachistima	−1	Upper slope	−1
Thuja-Tsuga/Pachistima	0	Middle slope	0
		Lower slope	+1
		Flat or bench	−4

$R^2 = 0.93$; $S\bar{y} = \pm 7.2$ feet.

Grand Fir Equation I:

$$GFht = +13.6 + 0.75(WPSI) + 0.80(A) - 1{,}260(1/WPSI) - 15(WPSI/A)$$

$R^2 = 0.94$; $S\bar{y} = \pm 7.6$ feet.

Grand Fir Equation II:

$$GFht = +54.1 + 1.8(WPSI) - 1{,}100(1/WPSI) - 0.014(WPSI \cdot A) - 25(WPSI/A) - 0.0022(E) + 1.8(CosAz) + 1.35(WPht) - 77(WPht/A) + HT\ value + TP\ value$$

Abies/Pachistima	−1	Ridge	+1
Thuja/Pachistima	0	Upper slope	−2
Thuja-Tsuga/Pachistima	+1	Middle slope	+3
		Lower slope	−2
		Flat or bench	+1

$R^2 = 0.96$; $S\bar{y} = \pm 6.3$ feet.

Western Hemlock Equation I:

$$WHht = +0.7 + 0.91(WPht)$$

$R^2 = 0.98$; $S\bar{y} = \pm 4.1$ feet.

Western Hemlock Equation II:

$$WHht = -16 + 0.33(A) + 45{,}000(1/E) + 0.65(WPht) + TP\ value$$

Ridge	−1
Upper slope	+3
Middle slope	0
Lower slope	−3
Flat or bench	+1

$R^2 = 0.99$; $S\bar{y} = \pm 3.4$ feet.

ESTIMATING WHITE PINE SITE INDEX

A second objective of this study was to provide a means for estimating white pine site index when white pine is absent, but when height and age of a common associate species can be measured. The equations that follow have a lower coefficient of determination and consequently a somewhat higher standard deviation from regression than the prediction equations for estimating tree height. They are shown graphically in Appendix C. Variables other than tree height and age contributed little increased accuracy to estimates; so more complex equations are omitted.

From Western Larch Height:

$$WPSI = -7.3 + 0.8(WLht) + 1{,}800(1/A) - 600(1/WLht) - 0.003(WLht \cdot A)$$

$$R^2 = 0.37;\ S\bar{y} = \pm 11.0 \text{ feet.}$$

From Lodgepole Pine Height:

$$WPSI = +33.8 + 1.1(LPht) - 1.2(A) + 600(1/A)$$

$$R^2 = 0.51;\ S\bar{y} = \pm 12.0 \text{ feet.}$$

From Douglas-Fir Height:

$$WPSI = -51.5 + 0.8(DFht) + 0.6(A) + 3{,}400(1/A) - 1{,}100(1/DFht) - 0.005(DFht \cdot A)$$

$$R^2 = 0.50;\ S\bar{y} = \pm 9.7 \text{ feet.}$$

From Grand Fir Height:

$$WPSI = -28.8 + 0.28(A) + 1{,}200(1/A) + 43(GFht/A) + HT \text{ value}$$

Abies/Pachistima	**+3**
Thuja/Pachistima	**0**
Thuja-Tsuga/Pachistima	**−3**

$$R^2 = 0.51;\ S\bar{y} = \pm 10.7 \text{ feet.}$$

From Western Hemlock Height:

$$WPSI = +37.9 + 1.1(WHht) - 1.0(A) + 500(1/A)$$

$$R^2 = 0.50;\ S\bar{y} = \pm 11.3 \text{ feet.}$$

DISCUSSION AND CONCLUSIONS

Estimating height of one species simply from measurements of another species has definite limitations. Different species are not equally sensitive to differences in various site factors; consequently, the relations between species-growth characteristics must become more complex as site variation increases. While several different physical environments may give a similar numerical site index for white pine, the relative height response of another species may differ at each location, depending on its reaction to the particular combinations of environmental conditions. For this reason, the use of the longer formula may be warranted on specific areas that are important.

Site indexes were not compared directly at this time because good site curves were not available for all of the species associated with western white pine. Also, results elsewhere[8 9 10] point out that comparisons of site indexes are most successfully applied within areas of fairly uniform environment. Since the environments within the western white pine type are characterized by extreme variation (even locally), future studies of comparative site index must identify and measure the important site variables that affect relations among the type-species.

While the prediction equations given in this paper can be useful in making management decisions, the user should be aware of their limitations. Many of the source data have been taken from plots in unmanaged second-growth stands. Conditions of density and species composition have no doubt affected height-growth relations differently than they would on intensively managed plots. These equations should be used with these limitations in mind.

[8] *Hodgkins, Earl J. Testing soil-site index tables in southwest Alabama. Jour. Forestry 54: 261-266. 1956.*

[9] *Foster, Ralph W. Relation between site indexes of eastern white pine and red maple. Forest Sci. 5:279-291. 1959.*

[10] *Della-Bianca, Tino, and David F. Olson, Jr. Soil-site studies in Piedmont hardwood and pine-hardwood upland forests. Forest Sci. 7:320-329. 1961.*

APPENDIX A

Graphs and a summary table predict the average dominant-codominant height of five species other than western white pine from white pine site index and stand age (Equation I series). Arrows show the direction in which graphs are to be read. The dashed portions of curves are extrapolations beyond actual data.

THESE GRAPHS AND THE SUMMARY TABLE ARE NOT TO BE USED FOR ESTIMATING WHITE PINE SITE INDEX.

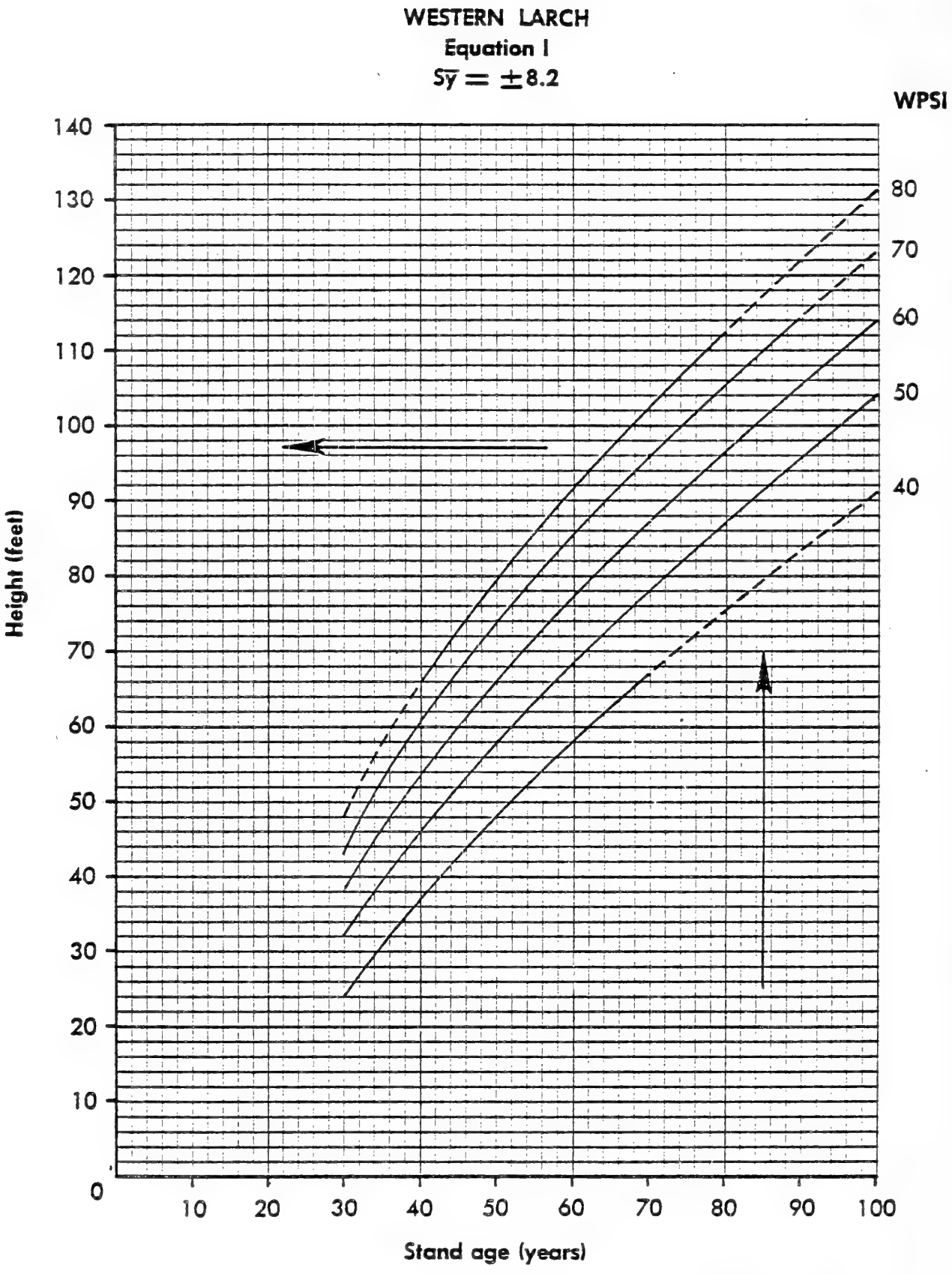

Figure 1. — Predicted average height of dominant and codominant trees by white pine site index and stand age.

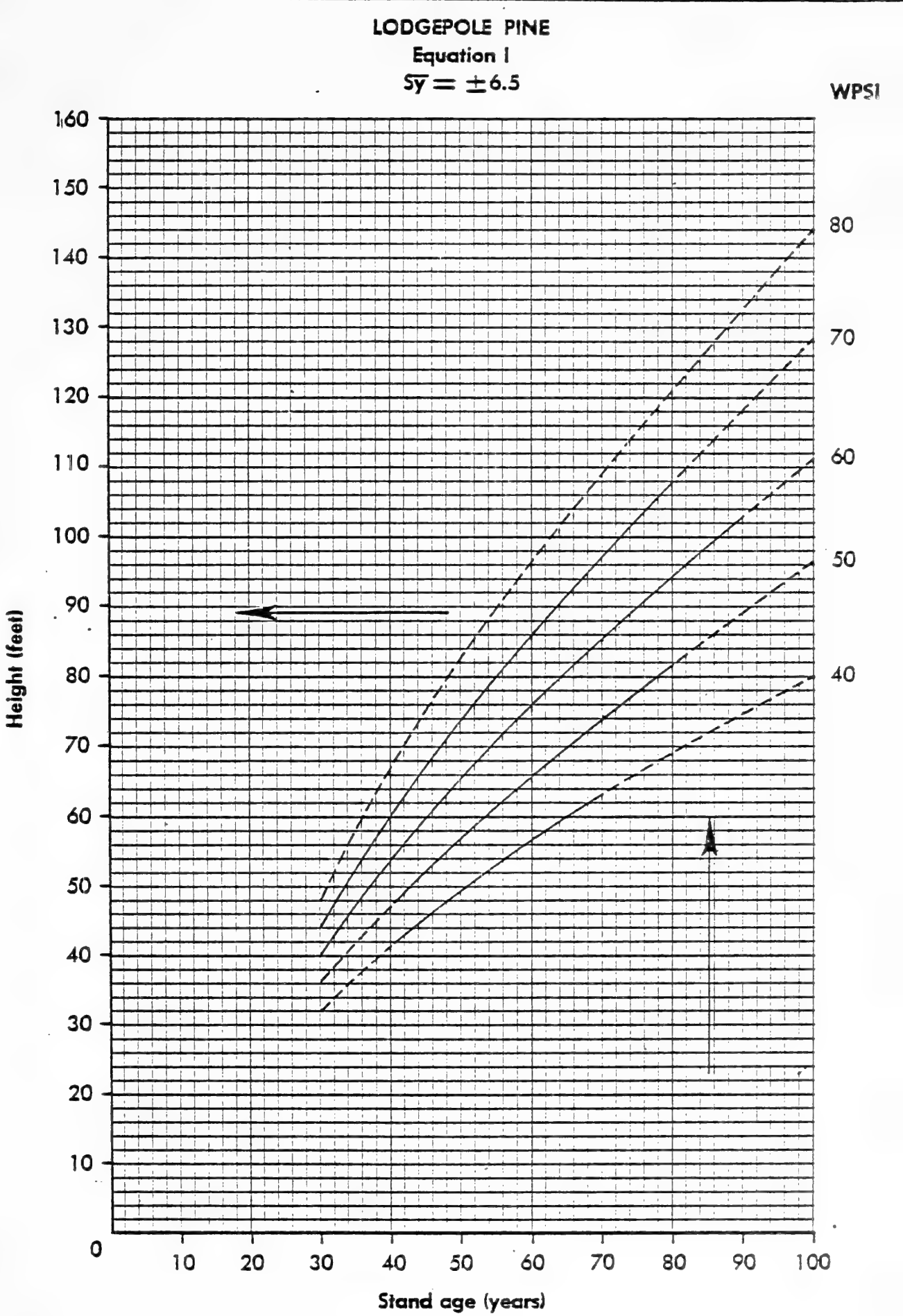

Figure 2. — Predicted average height of dominant and codominant trees by white pine site index and stand age.

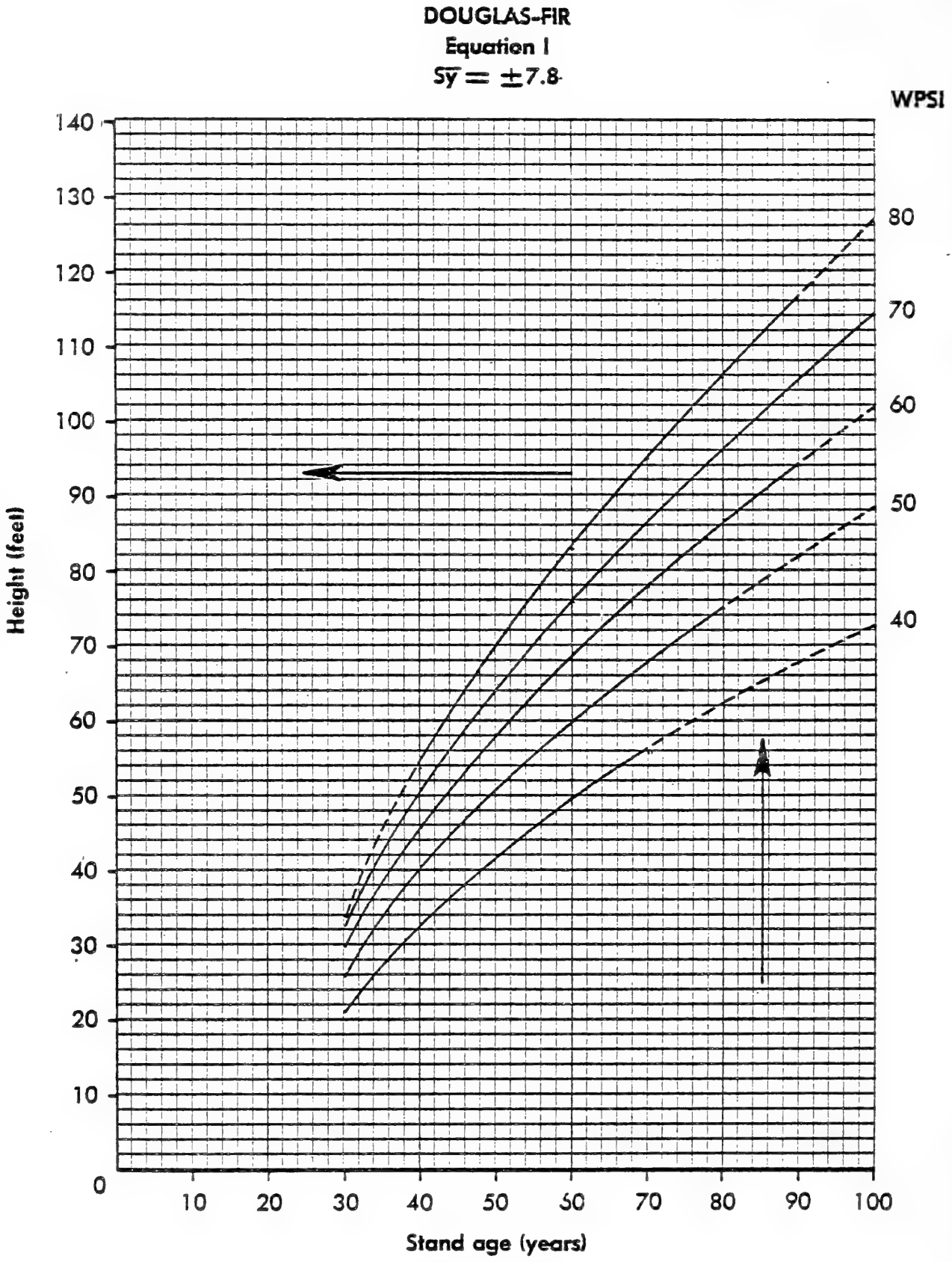

Figure 3. — Predicted average height of dominant and codominant trees by white pine site index and stand age.

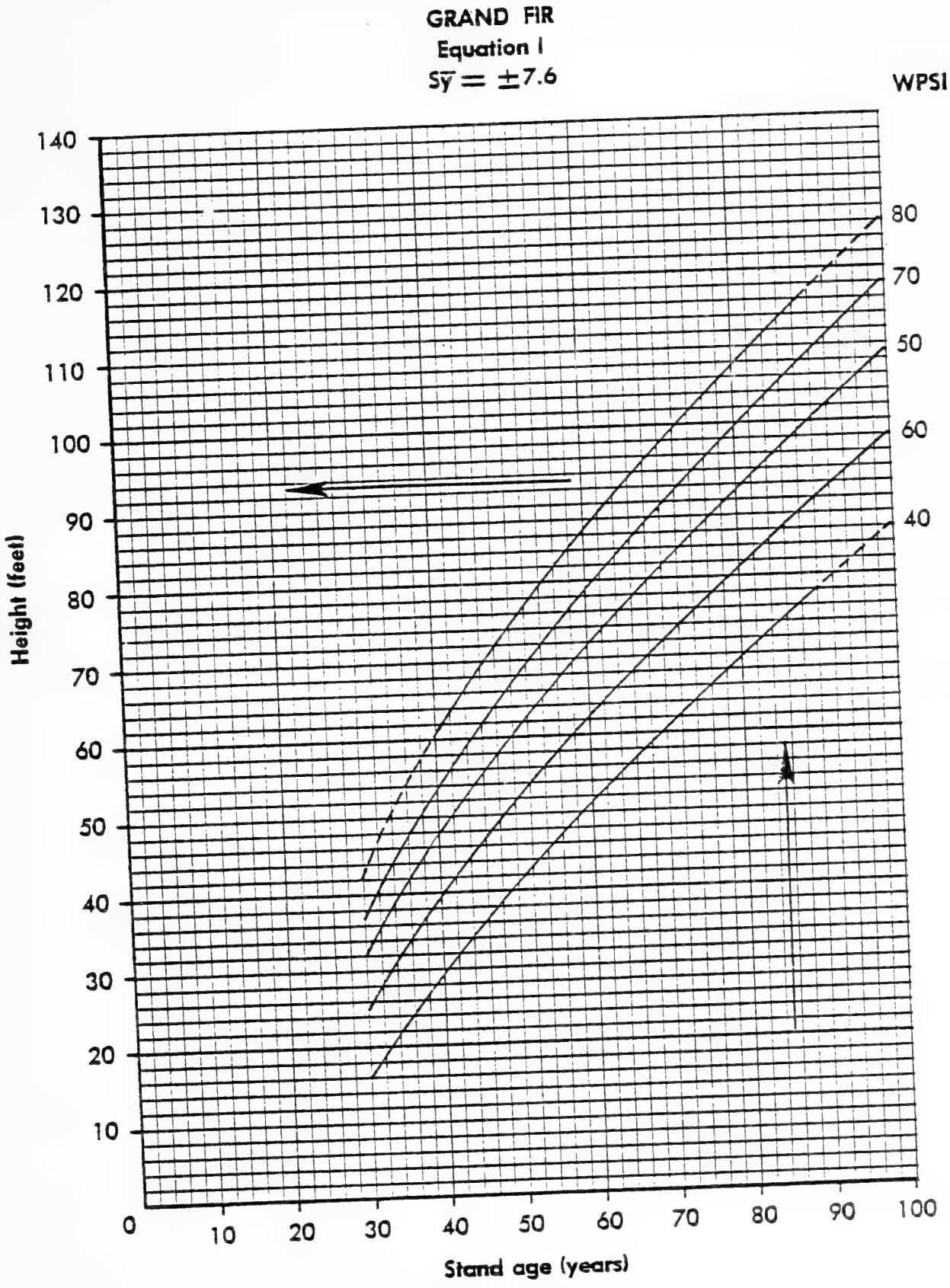

Figure 4. — Predicted average height of dominant and codominant trees by white pine site index and stand age.

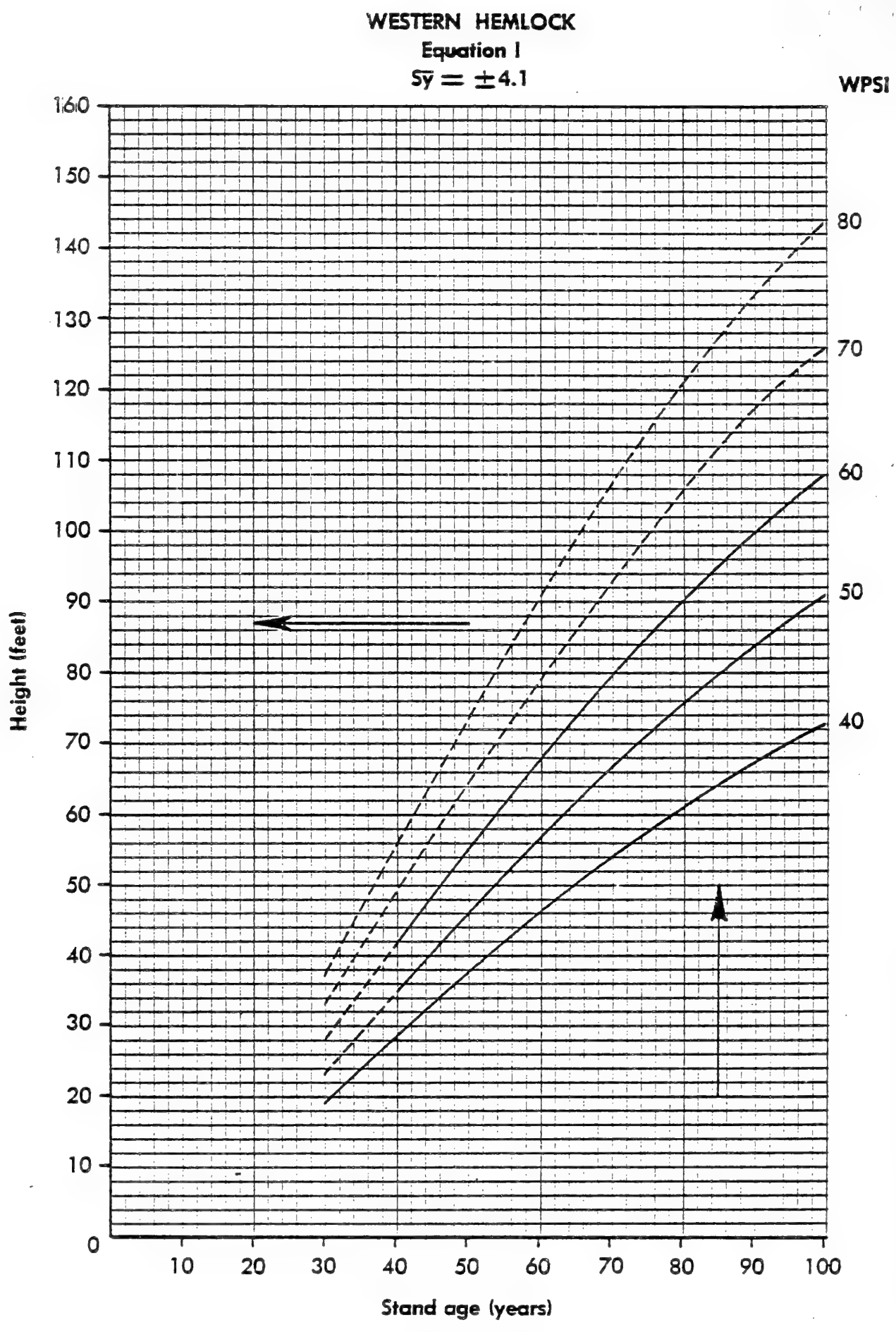

Figure 5. — Predicted average height of dominant and codominant trees by white pine site index and stand age.

Table 2.—Comparative heights of species by white pine site index and stand age

[Equation I series]

White pine site index	Stand Age	Species					
		White pine	Western larch	Lodgepole pine	Douglas-fir	Grand fir	Western hemlock
	Years	Height (feet)					
40	20	10	5	24	--	--	10
	30	20	24	32	21	16	19
	40	30	37	40	33	29	28
	50	40	48	48	42	40	37
	60	49	57	55	50	50	45
	70	58	66	63	56	60	53
	80	66	75	69	62	69	61
	90	73	83	75	68	78	67
	100	78	91	80	73	86	73
50	20	12	10	26	--	4	12
	30	25	32	36	26	25	23
	40	38	46	47	41	39	35
	50	50	58	56	51	51	46
	60	61	68	65	60	61	56
	70	72	78	74	68	71	66
	80	82	87	82	75	81	75
	90	91	95	90	82	90	84
	100	97	104	96	89	98	91
60	20	14	14	27	--	9	13
	30	30	38	40	30	32	28
	40	45	54	52	46	47	42
	50	60	67	64	58	60	55
	60	73	77	75	69	71	67
	70	86	87	85	78	81	79
	80	98	96	95	87	90	90
	90	109	105	104	95	100	100
	100	117	114	111	102	109	108
70	20	16	16	29	--	12	15
	30	35	43	44	33	37	33
	40	53	61	59	51	54	49
	50	70	74	72	65	67	64
	60	86	85	85	76	79	79
	70	101	96	98	87	89	93
	80	115	105	109	97	99	105
	90	128	114	119	106	108	117
	100	137	123	128	115	118	126
80	20	19	18	31	--	14	18
	30	40	48	48	34	42	37
	40	60	66	64	54	60	55
	50	80	81	81	70	74	74
	60	98	93	95	83	86	90
	70	116	103	110	95	97	106
	80	132	113	123	106	107	121
	90	145	122	133	117	116	133
	100	156	131	144	127	126	144

APPENDIX B

The following tables are for predicting the average dominant-codominant height of five species other than western white pine from white pine site index, stand age, and other site data (Equation II series).

These tables are included to facilitate calculations by the longer formula. To the "base value" obtained in the first table for a given species, add "adjustment values" for each of the other variables from the following tables for that species. For example, to find the height of western larch where:

White pine site index is 60 and stand age is 70 years	Base value	=	−65
Aspect is south (180° azimuth)	Adjustment value	=	−3
Elevation is 4,000 feet	Adjustment value	=	+141
Topographic position is ridge	Adjustment value	=	+12
Habitat type is *Abies/Pachistima*	Adjustment value	=	−9
	Total		76

. . . so the estimated larch height would be 76 feet.

WESTERN LARCH HEIGHT PREDICTION
(Equation II)

Table 3a.—Base values from stand age and white pine site index

Stand age (years)	White pine site index				
	40	50	60	70	80
20	−128	−131	−136	−143	−149
30	−118	−115	−114	−113	−114
40	−109	−103	−98	−95	−92
50	−101	−92	−86	−81	−76
60	−93	−83	−75	−69	−63
70	−84	−73	−65	−58	−51
80	−76	−64	−55	−47	−40
90	−68	−56	−46	−38	−30
100	−60	−47	−37	−28	−20

Table 3b.—Adjustment values for aspect

Azimuth	Adjustment value
0(360°)	+3
45°	+2
90°	0
135°	−2
180°	−3
225°	−2
270°	0
315°	+2

Table 3c.—Adjustment values for elevation

Elevation (feet)	Adjustment value
2,000	+168
2,500	+152
3,000	+144
3,500	+141
4,000	+141
4,500	+143
5,000	+147

Table 3d.—Adjustment values for topo position

Position	Adjustment value
Ridge	+12
Upper slope	+1
Middle slope	0
Lower slope	−1
Flat or bench	−12

Table 3e.—Adjustment values for habitat type

Habitat type	Adjustment value
Abies/Pachistima	−9
Thuja/Pachistima	+6
Thuja-Tsuga/Pachistima	+3

LODGEPOLE PINE HEIGHT PREDICTION

(Equation II)

Table 4a.—Base values from stand age and white pine site index

Stand age (years)	White pine site index				
	40	50	60	70	80
20	−111	−110	−109	−108	−108
30	−97	−96	−95	−95	−95
40	−91	−90	−89	−88	−88
50	−87	−86	−85	−84	−84
60	−84	−83	−82	−82	−81
70	−82	−81	−80	−80	−79
80	−81	−80	−79	−78	−78
90	−79	−78	−78	−77	−77
100	−78	−77	−77	−76	−76

Table 4b.—Adjustment values for white pine height

White pine height (feet)	Adjustment value
10	7
20	13
30	20
40	26
50	33
60	40
70	46
80	53
90	59
100	66
110	73
120	79
130	86
140	92
150	99
160	106
170	112
180	119
190	125
200	132

Table 4c.—Adjustment values for aspect

Azimuth	Adjustment value
0(360°)	+6
45°	+4
90°	0
135°	−4
180°	−6
225°	−4
270°	0
315°	+4

Table 4d.—Adjustment values for elevation

Elevation (feet)	Adjustment value
2,000	+117
2,500	+108
3,000	+105
3,500	+105
4,000	+106
4,500	+110
5,000	+114

Table 4e.—Adjustment values for topo position

Position	Adjustment value
Ridge	−1
Upper slope	−3
Middle slope	+5
Lower slope	+4
Flat or bench	−5

Table 4f.—Adjustment values for habitat type

Habitat type	Adjustment value
Abies/Pachistima	+6
Thuja/Pachistima	0
Thuja-Tsuga/Pachistima	−6

DOUGLAS-FIR HEIGHT PREDICTION
(Equation II)

Table 5a.—Base values from stand age and white pine site index

Stand age (years)	White pine site index				
	40	50	60	70	80
30	19	24	27	28	29
40	29	37	42	46	49
50	37	47	54	60	65
60	44	55	64	72	79
70	51	63	74	83	92
80	57	71	83	94	104
90	62	78	92	104	115
100	68	85	100	113	126

Table 5b.—Adjustment values for topo position

Position	Adjustment value
Ridge	+4
Upper slope	−1
Middle slope	0
Lower slope	+1
Flat or bench	−4

Table 5c.—Adjustment values for habitat type

Habitat type	Adjustment value
Abies/Pachistima	0
Thuja/Pachistima	−1
Thuja-Tsuga/Pachistima	0

GRAND FIR HEIGHT PREDICTION

(Equation II)

Table 6a.—Base values from stand age and white pine site index

Stand age (years)	White pine site index				
	40	50	60	70	80
20	37	46	52	57	62
30	49	59	69	77	84
40	51	63	73	81	90
50	51	62	72	80	88
60	48	59	68	76	84
70	45	55	63	71	77
80	41	51	58	64	70
90	37	45	51	57	61
100	33	40	45	49	52

Table 6b.—Grand fir adjustment values for white pine height and stand age

White pine height (feet)	Stand age (years)								
	20	30	40	50	60	70	80	90	100
10	−25	−12							
20	−50	−24	−12						
30	−75	−36	−17	−6					
40		−49	−23	−8	+3				
50		−61	−29	−10	+3	+13			
60			−34	−11	+4	+15	+23		
70			−40	−13	+5	+18	+27	+35	+41
80				−15	+5	+20	+31	+40	+46
90				−17	+6	+22	+35	+44	+52
100					+7	+25	+39	+49	+58
110					+7	+28	+43	+54	+64
120						+30	+46	+59	+70
130						+33	+50	+64	+75
140							+54	+69	+81
150							+58	+74	+87
160								+79	+93
170									+99

Table 6c.—Adjustment values for aspect

Azimuth	Adjustment value
0(360°)	+2
45°	+1
90°	0
135°	−1
180°	−2
225°	−1
270°	0
315°	+1

Table 6d.—Adjustment values for elevation

Elevation (feet)	Adjustment value
2,000	+4
2,500	+6
3,000	+7
3,500	+8
4,000	+9
4,500	+10
5,000	+11

Table 6e.—Adjustment values for topo position

Position	Adjustment value
Ridge	+1
Upper slope	−2
Middle slope	+3
Lower slope	−2
Flat or bench	+1

Table 6f.—Adjustment values for habitat type

Habitat type	Adjustment Value
Abies/Pachistima	−1
Thuja/Pachistima	0
Thuja-Tsuga/Pachistima	+1

WESTERN HEMLOCK HEIGHT PREDICTION
(Equation II)

Table 7a.—Base values from stand age

Stand age (years)	Base values
20	−9
30	−6
40	−3
50	0
60	+4
70	+7
80	+10
90	+14
100	+17

Table 7b.—Adjustment values for white pine height

White pine height (feet)	Adjustment value
10	6
20	13
30	20
40	26
50	32
60	39
70	46
80	52
90	58
100	65
110	72
120	78
130	84
140	91
150	98
160	104
170	110
180	117
190	124
200	130

Table 7c.—Adjustment values for elevation

Elevation (feet)	Adjustment value
2,000	+22
2,500	+18
3,000	+15
3,500	+13
4,000	+11
4,500	+10
5,000	+9

Table 7d.—Adjustment values for topo position

Position	Adjustment value
Ridge	−1
Upper slope	+3
Middle slope	0
Lower slope	−3
Flat or bench	+1

APPENDIX C

Graphs for estimating western white pine site index from stand age and the average dominant-codominant height of another species.

THESE GRAPHS ARE NOT TO BE USED FOR PREDICTING OTHER SPECIES HEIGHT.

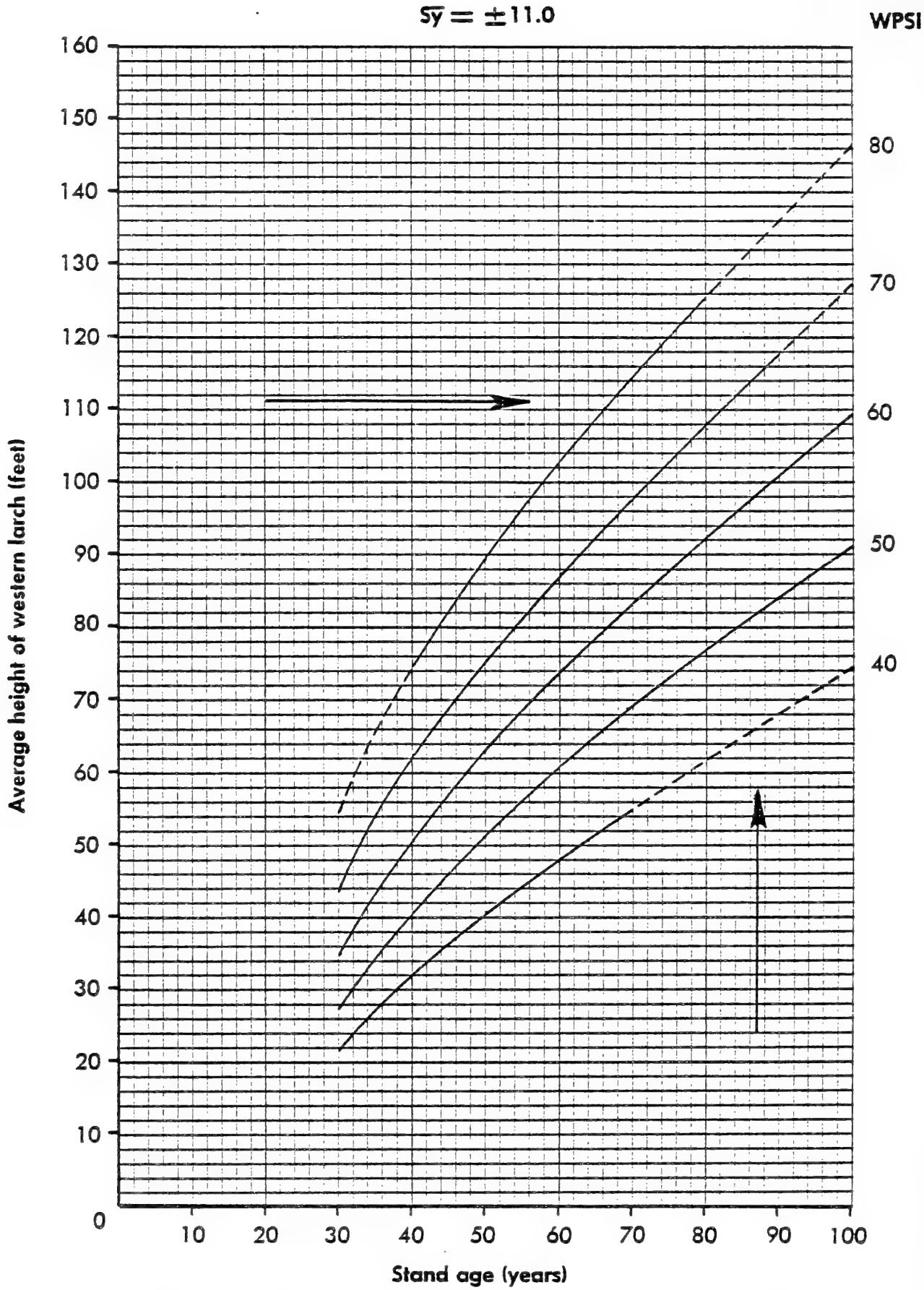

Figure 6. — Estimated western white pine site index by average height of dominant and codominant *western larch* and stand age.

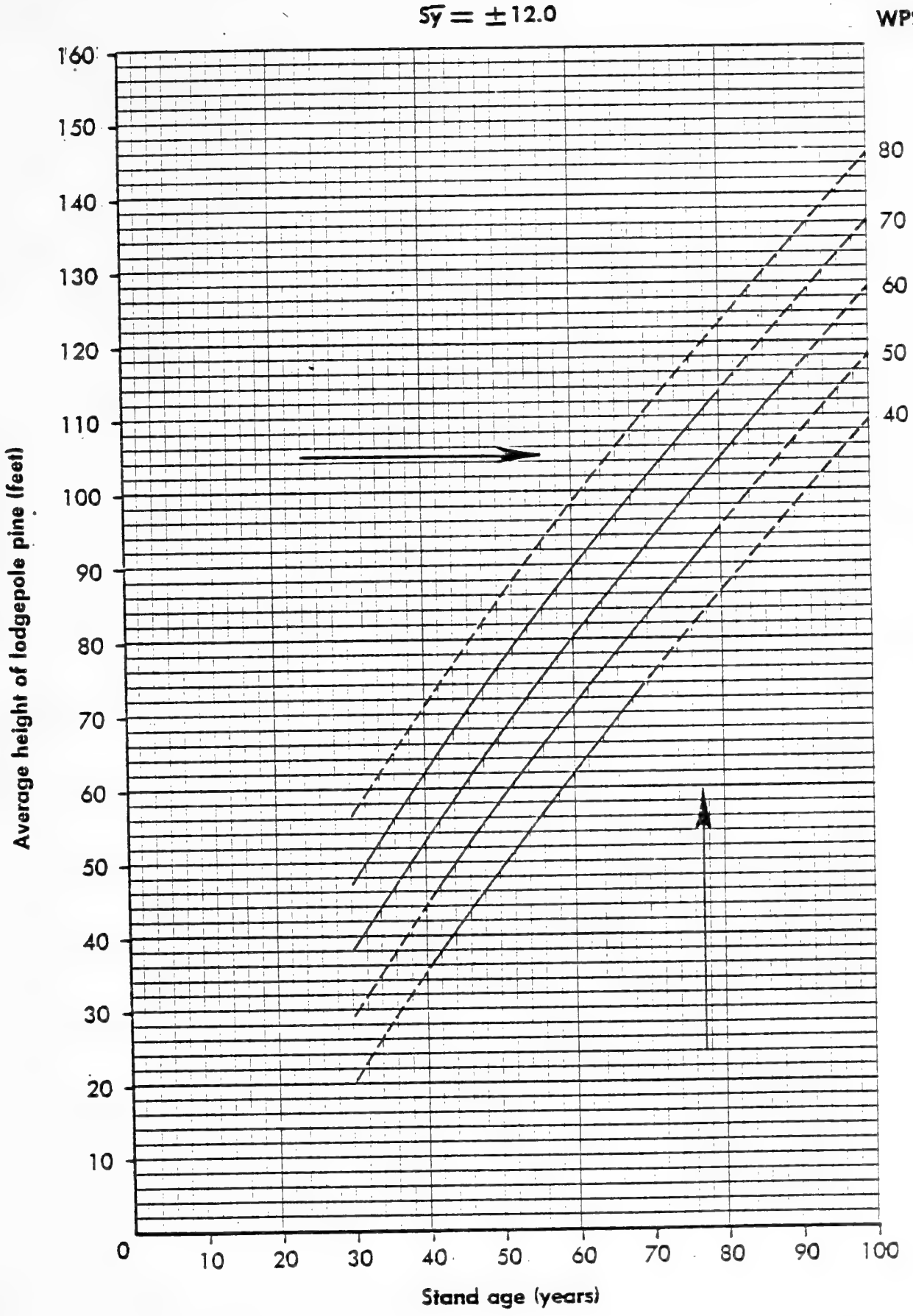

Figure 7. — Estimated western white pine site index by average height of dominant and codominant *lodgepole pine* and stand age.

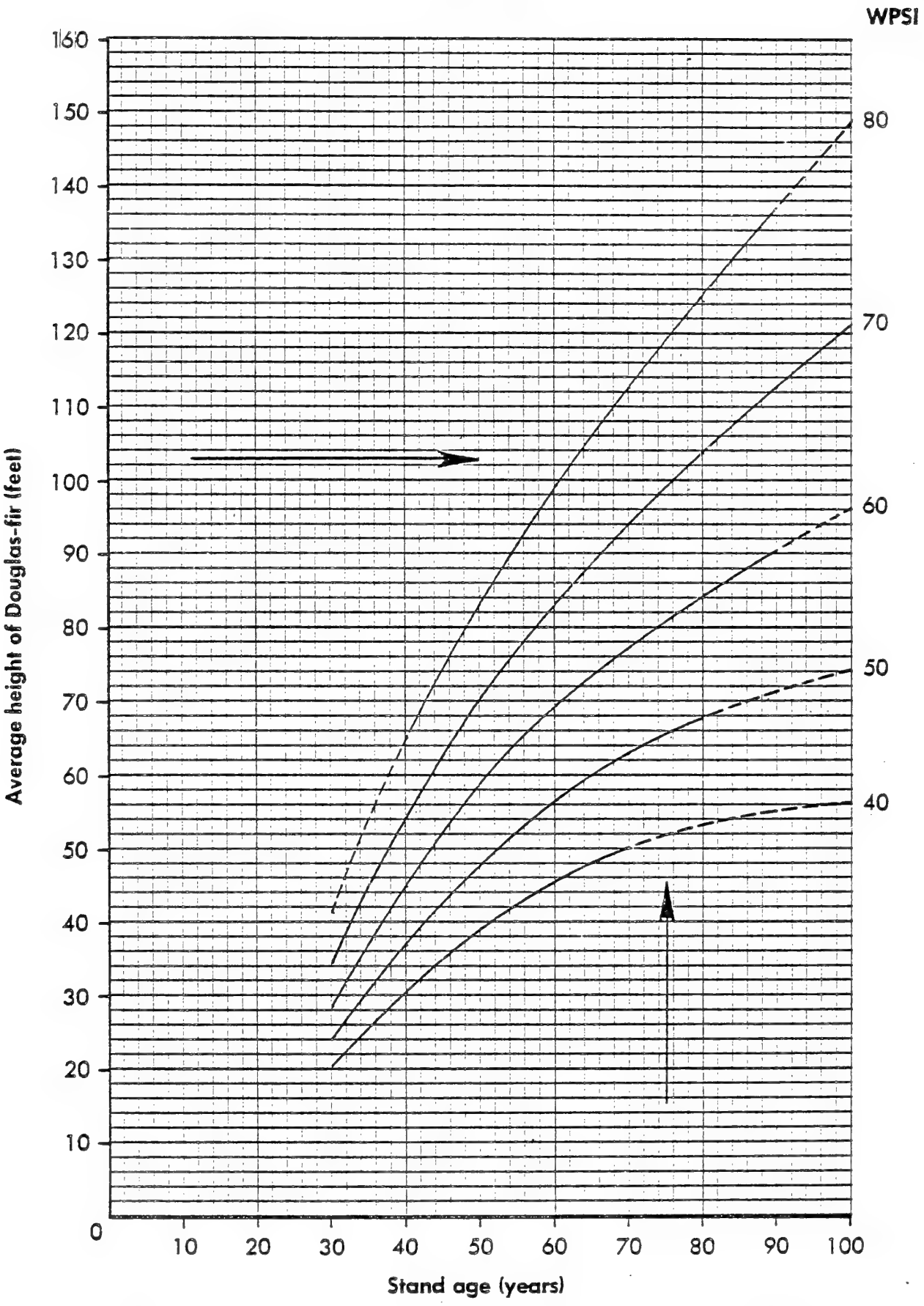

Figure 8. — Estimated western white pine site index by average height of dominant and codominant *Douglas-fir* and stand age.

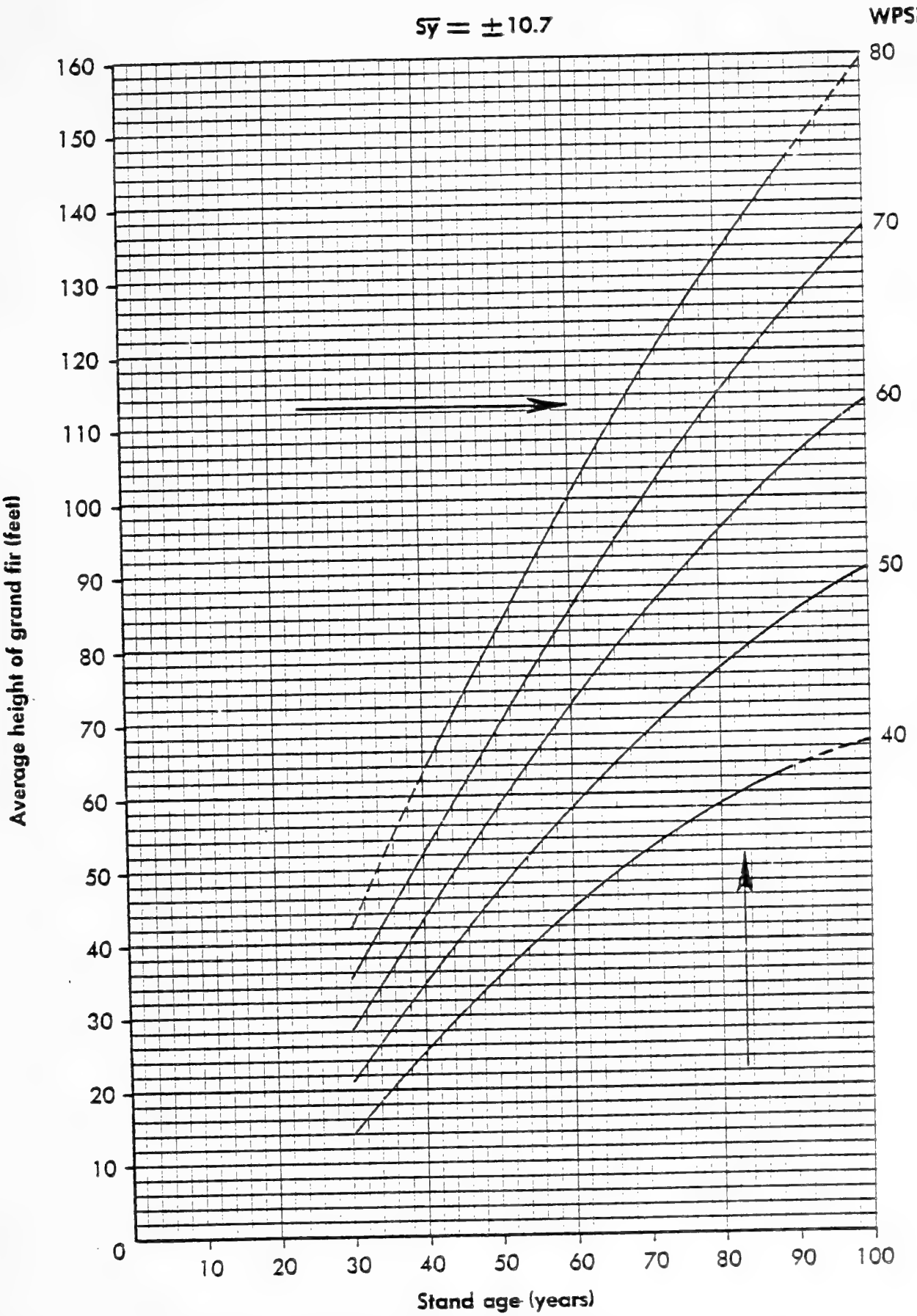

Figure 9. — Estimated western white pine site index by average height of dominant and codominant *grand fir* and stand age.

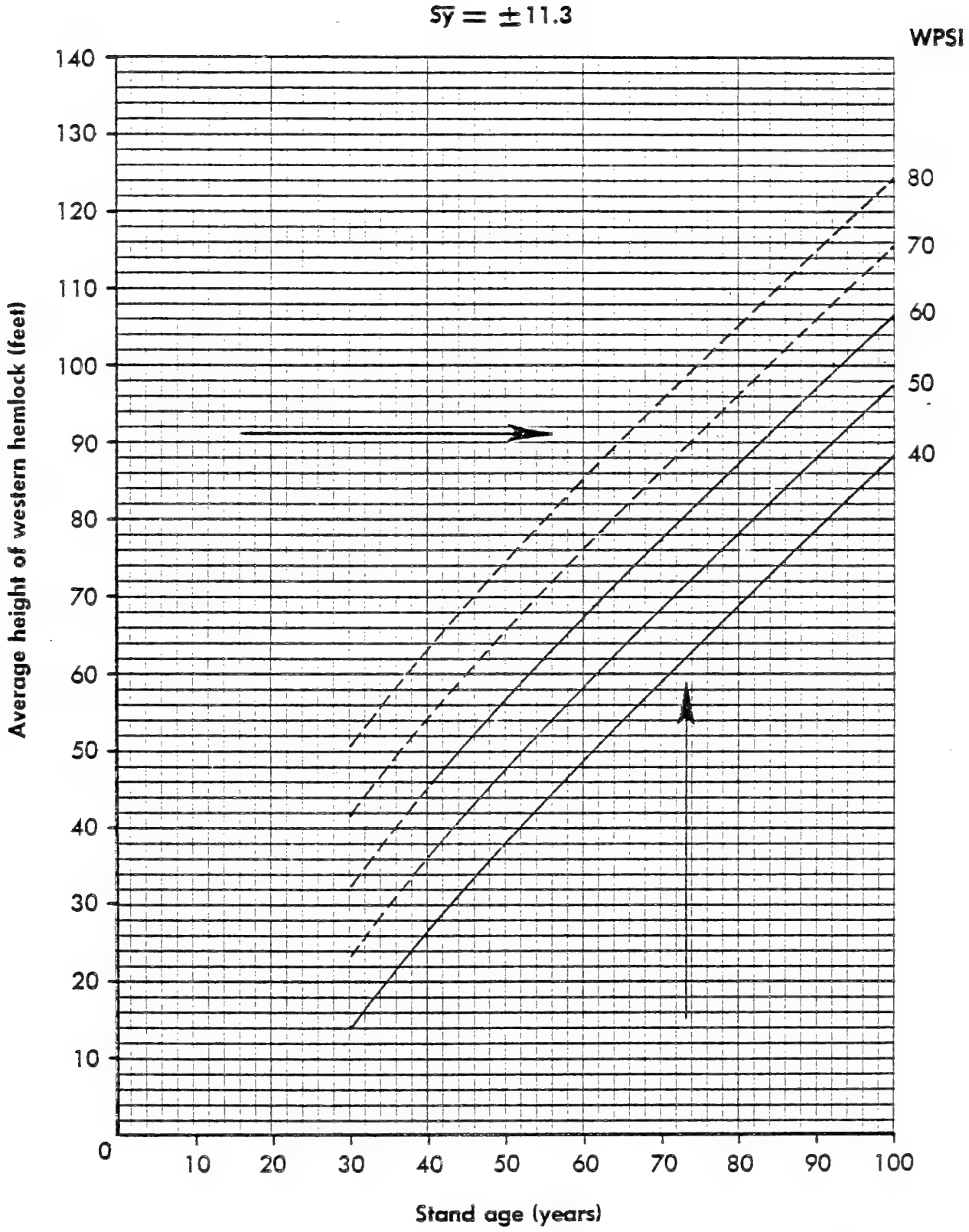

Figure 10. — Estimated western white pine site index by average height of dominant and codominant *western hemlock* and stand age.

FOREST SERVICE CREED

The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress — to provide increasingly greater service to a growing nation.

Deitschman, Glenn H., and Alan W. Green.

1965. Relations between western white pine site index and tree height of several associated species. U.S. Dept. Agr., Forest Serv., Intermountain Forest & Range Expt. Sta., Ogden, Utah. 28 pp., illus. (U.S. Forest Serv. Research Paper INT-22)

Records from 108 permanent plots in northern Idaho western white pine stands were analyzed to develop methods for estimating comparative height-growth capabilities among major species represented. Equations and graphs published here permit prediction of average dominant-codominant height of five associated species from site data that include stand age and white pine height or site index. Other equations provide estimates of white pine site index from known age and height of the alternate species. Many of the source data come from plots in unmanaged second-growth stands; hence, species-height relations shown here might differ from those in plantations or stands under management.

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Project headquarters are also at:

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